The Influence of Type Characteristics on Braille Reading

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Introduction

Ordinary printing comes in different sizes and styles and a sighted reader encounters many of these during the course of a day. For Blind persons who read Braille printing, there is little variation in the size and form of the printing. Most Braille printing has these standard characteristics; dot spacing .090 (distance between dots within the Braille cell); cell spacing .160 inches (horizontal distance between adjacent cells); line spacing .220 inches (vertical distance between lines).

The effect of the characteristics of ordinary printing on readability of visual materials has received considerable investigation. There has been comparatively little investigation , however, on the effects which Braille printing characteristics have on its readability.

A rather elaborate investigation of certain characteristics of Braille printing has been reported recently by Meyers, Ethington, and Ashcroft (1). Twenty-seven different types of Braille printing and 108 Blind Braille readers were used in this investigation. The investigation was repeated with

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1. This investigation was planned by Mr. Virgil Zickel and Dr. Samuel Ashcroft, of the American Printing House for the Blind and the late Dr. Ernest Meyers of the University of Kentucky. It was supported by a contract between the American Printing House for the Blind and the Kentucky Research Foundation. The experimentation and statistical analysis was done by Mr. James Clark who was employed as research assistant for this project. Actual experimentation was carried out in Chicago where 127 Blind Braille readers were used as subjects. This report has been prepared by Mr. Clark and Dr. James Calvin.

108 blind children as subjects. The results suggested that the following characteristics make Braille printing more readable: (1) dot spacing of .090" or .100" were superior to dot spacing of .080"; (2) cell spacing of .160" was superior to cell spacings of .123" and .140"; (3) line spacing of .220" was superior to line spacings of .163" and .300". This was an exploratory investigation and a wide variety of types of Braille printing (27 different types) was used. This permitted only four subjects for each of the 27 different printing types.

This is a report of a second investigation which was planned to use a small number of printing types (five) and a larger number of subjects (twenty) for each group. The five types of Braille printing used are indicated in the table below:

	Conventional Description			Description Used in This and Previous Investigation		
	Dot Space	Cell Space	Line Space	Dot Space	Cell Space	Line Space
(a)	.090"	.250"	.400"	.090"	.160"	.220"
(b)	.090"	.230"	.400"	.090"	.140"	.220"
(c)	.090"	.213"	.400"	.090"	.123"	.220"
(d)	.080"	.240"	.380"	.080"	.160"	.220"
(e)	.080"	.203"	.323"	.080"	.123"	.163"

These particular combinations were selected for the following reasons:

(a) These are the specifications for "standard Braille". This combination was found most readable by adults in the first investigation.

(b) This was read rapidly (but not most rapidly) by adults in the first investigation. If found to be easily readable, its printing would be economical.

(c) This combination was found most readable for child subjects in

the first investigation.

(d) This combination produced one of the slower reading rates in the first investigation.

(e) This combination would yield the largest number of Braille characters on a page. It was read relatively slowly by adults and children in the first investigation.

Procedure

A preliminary reading ability test was given to 127 blind persons. The material was chapters 12 and 13 from the book, The Black Arrow, by Robert Louis Stevenson, and it was embossed in standard Braille. All subjects were instructed to read as much of the material as possible without skipping words and they were told that they would be asked questions on the material they were to read. At the end of a 30-minute reading period comprehension of the material was tested by a list of twenty questions of the multiple-choice type.

Of these 127 subjects from the preliminary sessions, 100 were used as subjects for the main part of the experiment. These 100 subjects were assigned randomly to the five experimental groups. The remaining 27 persons were eliminated from the experimental analysis for the following reasons: (1) failure to comprehend at least 50 per cent of the preliminary material, as indicated by the comprehension test; (2) some subjects repeatedly fell asleep; (3) some subjects manifested disturbing spasms; (4) some subjects showed overt evidence of anxiety which lead to behavior which seemed to disrupt their reading; (5) failure to return for one of the experimental sessions; (6) failure to continue reading during the timed experimental sessions; (7) and finally, random elimination to reduce each group to 20 subjects.

As described above, there were 20 subjects in each of the five groups indicated in the table on page 2. The experimental periods consisted of two

fifty-minutes sessions on successive days for each subject. The material used was chapters 1-8 of The Black Arrow. During each session the experimenter recorded the time at the end of each alternate page. This permitted a measure of each subject's reading speed.

RESULTS

Initial Reading Speeds

There were no differences, except small ones which could be attributed to chance, in the initial reading speeds for the five groups of subjects. These were determined from the preliminary reading ability test. Group means and measures of variability are presented in Table I. From inspection of Table I it might appear that the .080" - .123" - .163" group had superior reading ability (91.09 words per minute) at the beginning of the experiment. However, statistical investigation by means of the analysis of variance technique (Table II) showed that these differences among the five groups are not large enough to be considered significant; they could have arisen from chance fluctuations. From this, it would seem reasonable to conclude that the random procedure of assigning subjects to the five experimental groups resulted in groups whose initial reading ability was essentially the same.

A distribution of reading abilities for all subjects (100) used in the experiment is shown in Figure 1. Inspection of this diagram indicates a wide range of reading abilities among the subjects used and the shape of the distribution (bell shaped) suggests that the subjects are probably a representative group of blind Braille readers. Inspection of Figure 1 suggests that the distribution follows the pattern of the "normal distribution"

TABLE I

Reading Speeds During Preliminary Test of Reading Ability

Group	Mean Reading Speed	Standard Deviation
090-160-220	78.59 words per minute	48.05
090-140-220	67.01 words per minute	39.64
090-123-220	74.38 words per minute	39.50
080-160-220	62.23 words per minute	32.34
080-123-163	91.09 words per minute	35.18

TABLE II

Analysis of Variance

Reading Speeds During Preliminary Test of Reading Ability

Source of Variation	Sum of Squares	Degrees of Freedom	Variance	F
Printing Types	9967.49	4	2491.87	1.62
Between Subjects Treated Alike	146788.59	95	1545.14	
Total	156756.08	99		

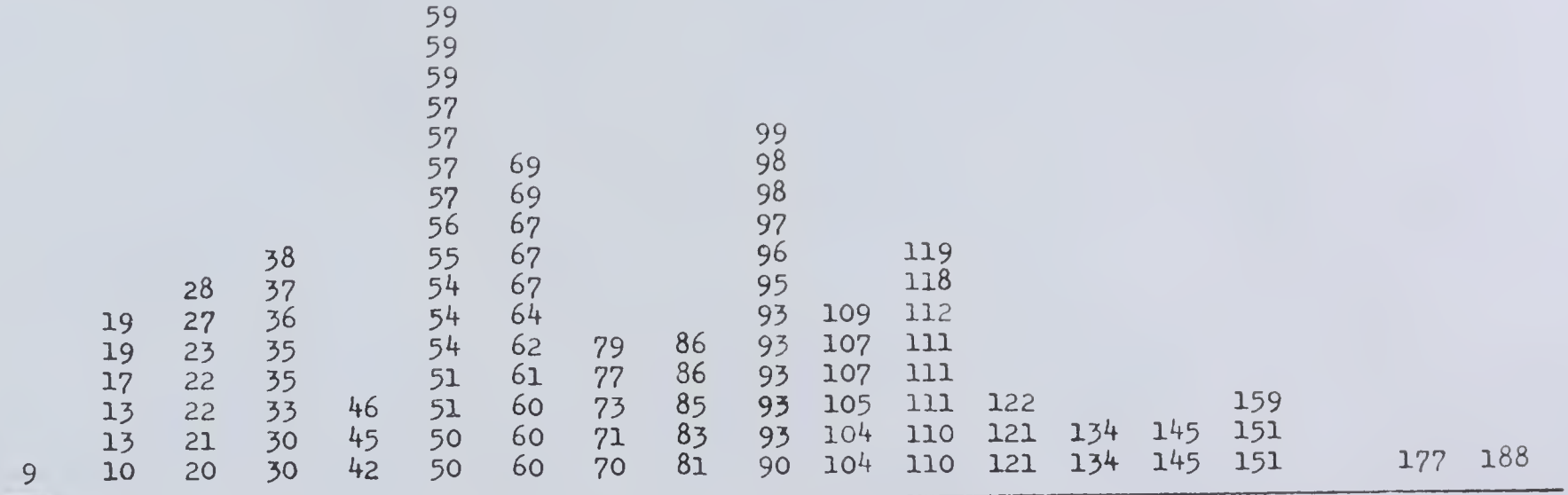

Figure 1

Distribution of Initial Reading Abilities for 100 Blind Braille Readers

which is usually found when scores from a representative group are plotted for some human ability. The obtained distribution appears from inspection to be fairly "normal" in shape. No statistical analysis has been performed to verify this, however.

Reading Speeds for the Experimental Materials

Average reading speeds for each of the five types of printing are presented in Table III. Corresponding measures from the previous investigation are also given for comparison. Inspection of these data suggests that the .090" - .160" - .220" combination was the most readable printing used, the .080" - .160" - .220" combination the least readable. In the latter case, however, the group of subjects which received the .080" - .160" - .220" printing was the lowest group in initial reading ability. Is their relatively low reading performance the result of their poor ability or because they received inferior printing?

In order to answer the question of whether these five groups differed in reading speed during the experimental sessions, an analysis of variance of the reading speed data was done. The results of this analysis, presented in Table IV, indicate that the differences among the five group means are not large enough to reach statistical significance.

Although the five groups did not differ significantly in their reading abilities on the preliminary test, as has been pointed out already, the differences seemed large enough to be noticeable if not significant. Group .080" - .123" -.163", the superior group in the preliminary test, read at a mean rate of 91.09 words per minute. In the experimental test, however, this group had dropped to fourth position out of the five groups

TABLE III

Reading Speeds For Five Types of Braille Printing

Printing Characteristics			Column.	Mean Reading Speed in Present Investigation	Mean Reading Speed in Previous Investigation
Dot Spacing	Cell Spacing	Line Spacing		20 subjects per group	4 subjects per group
.090"	.160"	.220"	3	81.81 words per min.	95.75 words per min.
.090"	.140"	.220"	4	70.98 words per min.	87.50 words per min.
.090"	.123"	.220"	2	72.59 words per min.	96.75 words per min.
.080"	.160"	.220"	5	57.07 words per min.	76.75 words per min.
.080"	.123"	.163"	4	67.73 words per min.	76.75 words per min.

TABLE IV

Analysis of Variance

Reading Speeds During Experimental Sessions

Source of Variation	Sum of Squares	Degrees of Freedom	Variance	F
Printing Types	12780.05	4	3195.01	1.94
Reading Periods	414.83	1	414.83	
Printing Types x Reading Periods	88.07	4	22.01	
Between Subjects Treated Alike	312752.55	190	1646.07	
Total	323035.51	199		

and the group read at a mean rate of 67.73 words per minute. On the other hand, the poorest group (.080"-.160"-.220") on the preliminary test remained the poorest group on the experimental tests; this group read at a mean rate of 62.23 words per minute on the preliminary test and 57.07 words per minute in the experimental tests.

From such comparisons between preliminary tests and experimental tests, it is difficult to make any definite conclusions about differences caused by the different printing types. A statistical technique called analysis of covariance permits in effect an adjustment of the data from the experimental sessions so as to equate all subjects for reading ability. It should be possible to use analysis of covariance to answer this question: If all subjects are equal in reading ability, will the difference in print types make any difference in thier reading performance? In this way, the effects of differences in reading abilities can be statistically ruled out. This analysis of covariance was done and the results are reported in Table V. This analysis indicates that the five groups do differ significantly in reading performance on the experimental materials (when differences in reading ability have been taken into account).

Mean reading speed for each of the five groups has been adjusted to equate for initial differences in reading ability. These adjusted means are presented in Table VI. From the analysis of covariance described in the preceding paragraph, we know that these adjusted means differ significantly. Inspection of Table VI indicates that the .090"-.160"-.220" and the .090"-.140"-.220" printing types resulted in superior reading performance and that the .080"-.123"-.163 printing type resulted in relatively poor reading performance.

TABLE V

Summary Table

Analysis of Covariance*

Source	SS	df	MS	F	Significance Level
Adjusted sum of squares within combinations	16,411.79	94	174.59		
Adjusted sum of squares between combinations	9,271.42	4	2,317.85	13.27	.01

*overall mean number of words per minute for the two sessions was used for each subject.

Table VI

Adjusted Reading Speeds for Five Types of Braille Printing

Group	Actual Mean Reading Speed	Adjusted Mean Reading Speed
090-160-220	81.81 words per minute	78.15 words per minute
090-140-220	70.98 words per minute	78.11 words per minute
090-123-220	72.59 words per minute	72.85 words per minute
080-160-220	57.07 words per minute	68.65 words per minute
080-123-163	67.73 words per minute	52.42 words per minute

There were two experimental sessions on consecutive days. Each session was fifty minutes in length. Were there any progressive changes in reading speed during a session or between sessions? For example, it is possible that the effects of practice could operate to improve reading performance. Or, on the other hand, fatigue effects could cause performance to deterioriate.

Information on this question has been obtained by subdividing each session into two halves (first 25 minutes and second 25 minutes). Reading speeds for each half of the two sessions are presented in Table VII and these results are plotted graphically in Figure 2. Inspection of Figure 2 suggests a slight general trend toward improved reading speed between the first and second experimental sessions for all groups of subjects. From graphic inspection this trend appears fairly slight and it is questionable whether the degree of trend is significant. To answer this question of significance, a trend analysis (2)was done and it was found that the degree of trend was significant. This trend analysis is presented in Table VIII.

Immediately following the second experimental session, each subject was asked several questions aimed at discovering his subjective impressions formed while reading his Braille materials. These questions and a tabulation of the answers given by the subjects in each group appear in Table IX.

TABLE VII

Changes in Reading Speed During Experimental Sessions

Group	Session 1		Session 2	
	First Half	Second Half	First Half	Second Hal
090-160-220	80.06	78.80	84.45	83.16
090-140-220	70.68	70.47	72.45	70.19
090-123-220	72.19	69.99	74.29	73.73
080-160-220	57.06	53.65	59.42	58.12
080-123-163	68.99	63.88	69.71	68.48

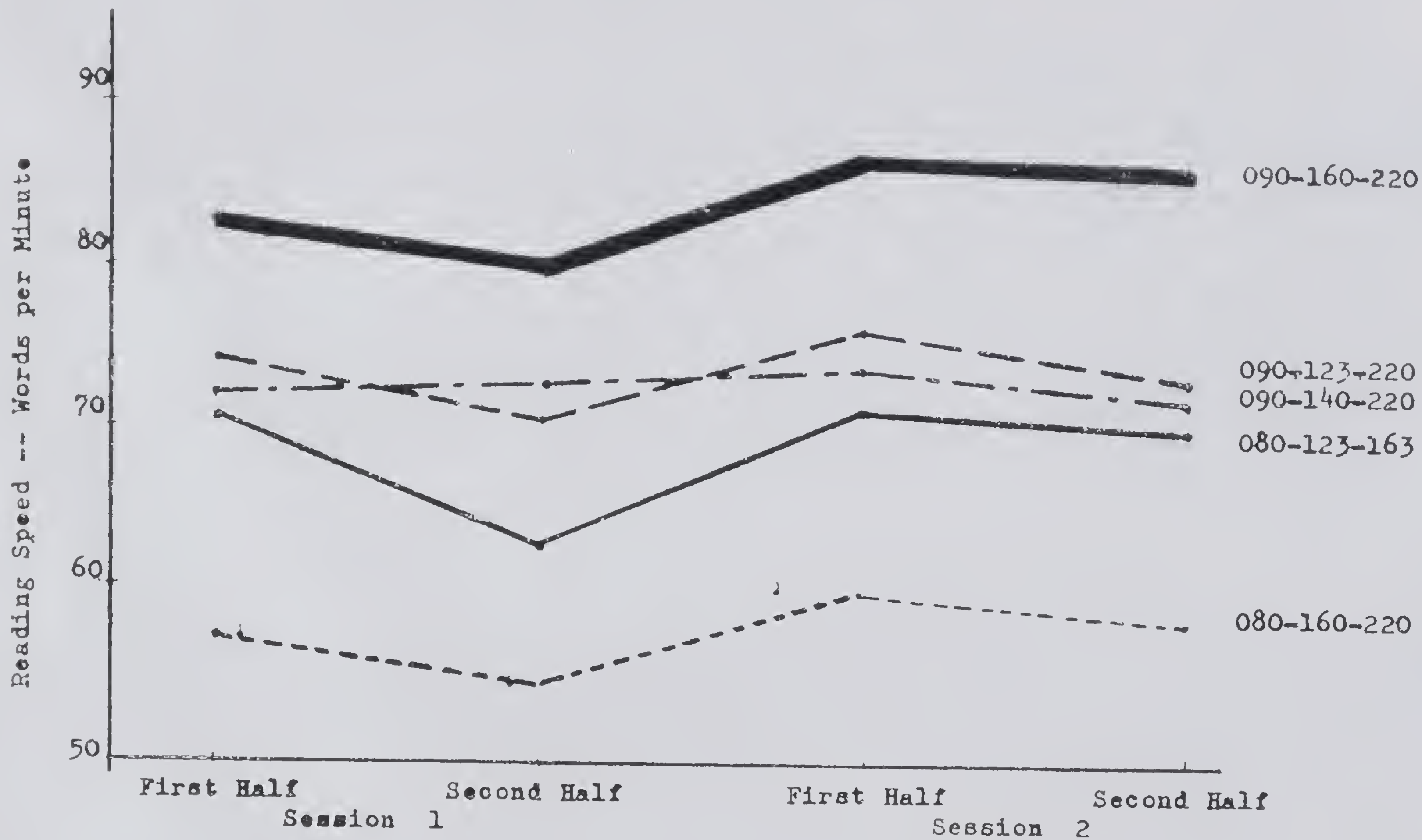

Figure 2
Changes in Reading Rate With Practice

TABLE VIII

Trend Analysis

Source of Variation	Sum of Squares	Degrees of Freedom	Variance	F	Signific
Group Means	25177.67	4	6294.41	373.77	.0
Individual Means	619240.12	95	6518.31	387.07	.0
Overall Slope	334.82	1	334.82	19.88	.0
Between Group Slopes	70.20	4	17.55	1.04	
Between Individual Slopes	4127.66	95	43.44	2.57	.0
Overall Deviation from Linearity	848.38	2	424.19	25.18	.0
Group Deviations from Estimation	231.75	8	28.96	1.71	
Individual Deviations from Estimation	3199.68	190	16.84		
Total	653230.28	399			

Comparison with Previous Investigation

As described in the introduction to this report, this investigation employed five printing types out of twenty-seven which had been used in the Meyers, Ethington, and Ashcroft (1) experiment. How do the results of the two investigations compare? The mean reading speeds obtained in each experiment are presented in Table III. Comparison of these results appears striking in two ways:

1. In the present investigation, mean reading speed was consistently lower than in the previous investigation. The probable reason for this discrepancy is that a superior group of readers, including many teachers for the blind, was used as subjects in the previous investigation. It seems likely that the subjects in the present investigation were a more representative group of Braille readers. This can be supported by comparing the distribution of initial reading abilities for the subjects in this investigation (Figure 1) with a corresponding distribution for subjects from the preceding investigation. Although the ranges of the two distributions are comparable, the bulk of the subjects in the present investigation fall at lower reading abilities.

2. The relative positions of the various groups appear to show some consistency between the two investigations. From scanning the table of results (Table III), it can be seen that the .090" - .160" - .220" group ranked highest in this investigation. In the previous investigation it was in second place with respect to the five printing types used in the present experiment, but almost high enough for first place. The .080" - .160" - .220" group ranked lowest in this investigation and it was tied for lowest place in the previous investigation.

The correspondence between the two sets of ranks seems fairly strong. To this extent, the results of this experiment corroborate those of the first investigation.

TABLE IX

Answers to Questions At End of Experiment

Question 1: Is this Braille the same or different from what you are used to?

	Same	Different	Don't Know
090-160-220	9	9	2
090-140-220	7	11	2
090-123-220	7	11	2
080-160-220	9	11	0
080-123-163	1	18	1

Question 2: Are the dots in a character the same, farther apart, or closer than what you are used to?

	Same	Farther Apart	Closer	Don't Know
090-160-220	10	1	8	1
090-140-220	3	3	10	4
090-123-220	2	0	17	1
080-160-220	8	2	7	3
080-123-163	3	0	17	0

Question 3: Are the lines the same, farther apart, or closer than what you are used to?

	Same	Farther Apart	Closer	Don't Know
090-160-220	11	2	6	1
090-140-220	5	4	7	4
090-123-220	13	0	4	3
080-160-220	13	2	4	1
080-123-163	3	0	16	1

Question 4: Are the cells the same, farther apart, or closer than what you are used to?

	Same	Farther Apart	Closer	Don't Know
090-160-220	10	2	7	1
090-140-220	7	4	6	3
090-123-220	5	0	13	2
080-160-220	9	1	8	2
080-123-163	5	1	14	0

Question 5: Is this Braille the same, better, or worse than the Braille you are used to?

	Same	Better	Worse	Don't Know
090-160-220	10	5	4	1
090-140-220	7	2	10	1
090-123-220	7	0	12	1
080-160-220	8	3	8	1
080-123-163	2	2	15	1

DISCUSSION

This experiment has corroborated the results of the Meyers, Ethington, and Ashcroft (1) investigation in finding that standard Braille printing (the .090" - .160" - .220" Combination) is read more rapidly that most other types of Braille printing. Out of the five types of Braille printing used in the present investigation, standard Braille was the most readable.

Standard Braille may be more readable than other types of Braille printing for either or both of two reasons; (1) it may be more readable because it combines superior printing characteristics; or (2) it may be more readable because it is the printing type (out of the five used) with which the subjects had previous experience. Favorable printing characteristics or familiarization from past experience - - which of these accounts for the superiority of "standard Braille"? This question cannot be answered conclusively from the results of this experiment. To provide a conclusive answer, it would be necessary for different groups of Blind persons to learn Braille reading on different types of Braille printing. This would rule out the factor of past experience which complicates interpretation of the results of the present experiment.

The fact that a printing type (.090" - .140" - .220") other than standard Braille (.090" - .160" - .220") proved just as readable when data was adjusted so as to equalize statistically initial reading ability suggests that there is nothing inherent in standard Braille which makes it superior to other types.

The .090" dot spacing types are superior consistently to .080" dot spacings. The Meyers, Ethington, and Ashcroft investigation showed that .090" dot spacings were as effective as .100" dot spacings. Taken together, the results of both investigations indicate that dots within a Braille cell can be too closely spaced and that a critical value exists between spacings of .080" and .090".

The .080" - .123" - .163" was the least readable printing used in this experiment. This is the most compact, closely spaced printing used in the experiment. As pointed out in the introduction to this report, this combination would yield the largest number of Braille characters on a page and it would be economical commercially for this reason. But it is the combination (out of the five used) which was most difficult to read. It would appear that the printing is so closely spaced that reading efficiency is lost.

There are several kinds of close spacing: nearness of dots within the Braille cell; nearness of adjacent cells in a horizontal line of print; nearness of two lines of print. The consistent superiority of .090" over the .080" spacings suggests that spacing of dots within the cell may be the most important of these.

SUMMARY

In an investigation of the readability of Braille printing the five following types of Braille printing were used: (1) .090" (distance between dots); .160" (distance between Braille cells in a line of print); .220" (distance between lines of Braille print); (2) .090" - .140" - .220"; (3) .090" - .123" - .220"; (4) .080" - .160" - .220"; (5) .080" - .123" - .163". A different group of twenty blind Braille readers was assigned to read each of these five types of printing. Each person was used for three sessions: a preliminary session for assessment of reading ability; two experimental sessions of fifty minutes each.

The results obtained indicated that the .090" - .160" - .220" (Standard Braille) and .090" - .140" - .220" combinations were read most rapidly, the .080" - .123" - .163" combination was read least rapidly. .090" dot spacings were consistently superior to .080" dot spacings (distance between dots within a Braille cell).

References

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2. Alexander, H. W. A general test for trend. Psychological Bulletin, 1946, 43, 533-557.

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